

## DESCRIPTION

DISPLAY APPARATUS, DISPLAY CONTROL METHOD, PROGRAM AND

RECORDING MEDIUM

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## TECHNICAL FIELD

The present invention relates to a display apparatus,  
a display control method, and a program and recording medium  
10 thereof.

## BACKGROUND ART

A conventional display apparatus for displaying  
15 characters and the like using a display device capable of  
color display is known as described in, for example, Japanese  
Laid-Open Publication No. 2001-100725 where a "character  
display apparatus" is disclosed.

20 Characters displayed by the "character display  
apparatus" are each made of a basic portion corresponding  
to the core (central skeleton) of the character and a  
neighboring portion arranged in the vicinity of the basic  
portion. The character display apparatus has a display

screen containing a plurality of pixels, each of which contains a plurality of subpixels. The basic portion and neighboring portion of a character are assigned different subpixels.

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In the character display apparatus, while the color element levels of the subpixels of a basic portion are set to a predetermined luminance level, the color element levels of the subpixels of the neighboring portion are set to a 10 luminance level different from that of the basic portion. The number of subpixels and the color element levels of the subpixels in the neighboring portion are determined in accordance with a correction pattern.

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Figure 12 is a diagram showing a character "/" (slash) displayed by a character display apparatus as disclosed in Japanese Laid-Open Publication No. 2001-100725, where the character "/" is represented only by the basic portion whose color element level is set to a predetermined luminance level.

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Hatched rectangles in Figure 12 represent subpixels corresponding to the basic portion of the character "/" (slash). When the color element level of a subpixel is set to a luminance level ranging from 0 to 255, the color element

levels of subpixels corresponding to the basic portion of the character "/" are set to, for example, a luminance level "0".

5           On the other hand, open rectangles represent subpixels corresponding to the background of the character "/". The color element levels of the subpixels corresponding to the background of the character "/" are set to a luminance level "255".

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Figure 13 is a diagram showing the character "/" (slash) displayed by a character display apparatus as disclosed in Japanese Laid-Open Publication No. 2001-100725, where the color element level of the basic portion is set 15 to a predetermined luminance level (luminance level 0) and the color element level of the neighboring portion(s) is set to a luminance level different from the luminance level ("0") of the basic portion.

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In Figure 13, neighboring portions on each lateral side of each of the subpixels corresponding to the basic portion of the character "/" are set to "luminance level 73", "luminance level 182", and "luminance level 219" in order of distance from the basic portion, the nearest first,

in accordance with a predetermined correction pattern.

5 Note that "assign luminance levels to the color element levels of subpixels of a neighboring portion in accordance with a correction pattern" is referred to as "provide a correction pattern".

10 The purposes of provision of a correction pattern include: suppression of color noise; recognition of characters or graphics as being black by human eyes; and adjustment of the apparent thickness of characters to a desired size.

15 Thus, according to the "character display apparatus" of Japanese Laid-Open Publication No. 2001-100725, characters can be displayed with high definition by providing the correction pattern for subpixels neighboring subpixels corresponding to the basic portion of a character.

20 Further, in the character display apparatus of Japanese Laid-Open Publication No. 2001-100725, subpixels corresponding to the basic portion are determined based on character outline information indicating the outlines of characters or skeleton data indicating the skeletal shapes

of characters.

The character outline information includes character codes for identifying the types of characters, 5 the number of strokes constituting each character (the stroke count of a character), and stroke information on each stroke.

The stroke information includes stroke codes for identifying a plurality of strokes, the number of contour points constituting each stroke, and a pointer for the coordinate data of contour points constituting each stroke (an address in an auxiliary memory device at which the coordinates of the contour points constituting the stroke are stored). From this information, the coordinates of the 10 contour points constituting a stroke can be obtained. In this case, each stroke has a shape enclosed by a contour line approximated by curved lines, straight lines, arcs, a combination thereof, or the like, and a predetermined thickness so as to display the contour shape of a character. 15

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A contour line representing the contour shape of a character can be approximated by straight lines, curved lines, arcs, a combination thereof, or the like, using the coordinate data of contour points. The contour line is scaled in

accordance with the size of an input character. This scaling converts the coordinate data of contour points to a coordinate system for a display device. A sub-pixel is determined as corresponding to a basic portion representing the core of  
5 a character depending on an area where a region enclosed by a contour line overlaps a sub-pixel, for example, if the area is greater than or equal to a predetermined area.

Skeleton data includes character codes for  
10 identifying the type of character, the number of strokes constituting each character, and stroke information on each stroke.

The stroke information includes stroke numbers for  
15 identifying respective strokes, the number of points constituting each stroke, the line type of each stroke (curved line, straight line, or the like), the coordinates of points constituting each stroke, and the like. In this case, each stroke does not have a thickness and is in the form of a  
20 line of a certain line type corresponding to the basic portion of a character.

If the line type of a stroke is a straight line, the stroke can be approximated by a straight line passing through

the coordinate data of a plurality of points constituting  
the stroke. If the line type of a stroke is a curved line,  
the stroke can be approximated by a curved line passing through  
the coordinate data of a plurality of points constituting  
5 the stroke.

The coordinate data of points constituting each  
stroke is scaled in accordance with the size of an input  
character and is converted into a coordinate system for a  
10 display device. Subpixels present on each scaled stroke are  
determined as subpixels corresponding to a basic portion  
representing the core (skeletal shape) of a character.

Japanese Laid-Open Publication No. 2002-49366  
15 discloses a technique for associating a basic portion of  
a character or graphics with subpixels using bitmap data.  
This technique will be described in detail below.

20 Bitmap data contains a plurality of bits arranged  
in a matrix of a plurality of rows and a plurality of columns.

Bitmap data is binary data containing bits. Each  
of the bits constituting bitmap data has a value of "1" or  
"0". A bit having a value of "1" indicates, for example,

a black color, while a bit having a value of "0" indicates a white color.

It is determined whether or not each of bits  
5 constituting bitmap data has a value of "1". An arrangement pattern of "1"/"0" values of bits neighboring a bit of interest is investigated. The bit of interest is associated with a pixel of a display screen. Based on the arrangement pattern of neighboring bits, subpixel(s) corresponding to the basic portion are determined from among the subpixels contained  
10 in a pixel corresponding to the bit of interest.

A "display apparatus" which controls the luminance of a display device in accordance with a surrounding environment, is disclosed in Japanese Laid-Open Publication  
15 No. 6-214508.

In this "display apparatus", a sensor for sensing ambient brightness is provided in the vicinity of the display device.  
20 By adjusting the luminance and contrast of the entire display device in accordance with the ambient brightness sensed by the sensor, the screen display can be made more viewable.

When the above-described conventional "character display apparatus" disclosed in Japanese Laid-Open Publication No. 2001-100725 is used under conditions that brightness is uniform (e.g., the apparatus is used as a liquid crystal display device for a notebook type personal computer),  
5 characters do not suffer from the color noise problem.

However, it is conceived that the above-described "character display apparatus" can be used under conditions  
10 wherein brightness is not uniform.

Brightness is not uniform, for example, when the above-described "character display apparatus" is used as  
15 the liquid crystal display device of a mobile telephone.

In liquid crystal display devices, when the surrounding environment is dark, the backlight is turned on so that the display screen is irradiated by the backlight and display is performed in a transmission mode. When the  
20 surrounding environment is bright, the backlight is turned off for the purpose of reduction of power consumption. In this case, ambient light incoming to the display screen is reflected by the reflection portion so that display is performed in a reflection mode. Thus, an arrangement which

controls display by switching the two modes, is known. In this arrangement, the characteristics of the device are changed depending on the on/off state of the backlight.

5           Therefore, if correction patterns are predetermined so as to be suitable for the case where the backlight is turned on, the correction pattern is conspicuous as color noise when the backlight is turned off. Further, when the  
10          backlight is turned off, the thickness of a character may be perceived on the dark display screen as being greater than that which is perceived when the backlight is turned on.

15          On the other hand, if correction patterns are predetermined so as to be suitable for the case where the backlight is turned off, the correction pattern is conspicuous as color noise when the backlight is turned on. Further, when the backlight is turned on, the thickness of a character may be perceived on the bright display screen as being smaller than that which is perceived when the  
20          backlight is turned off.

Some recent mobile telephones can adjust the brightness (irradiation level) of the backlight in a stepwise

manner rather than simply switching the backlight on/off. Also in this case, similarly, color noise occurs and/or a change in the apparent thickness of a character occurs, depending on the brightness of the backlight.

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The above-described problems also occur in the case of a frontlight or a sidelight in addition to a backlight.

A display apparatus utilizing a frontlight has the  
10 following structure and function. The frontlight is provided at a front side of a display screen. When the surrounding environment is bright, the frontlight is turned off so that ambient light incoming to the display screen is reflected by the reflection portion and display performed  
15 in a reflection mode. When the surrounding environment is dark, the frontlight is turned off and the display screen is irradiated by the frontlight so that display is performed in the transmission mode. In this case, the above-described problem occurs similarly.

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A display apparatus utilizing a side light has the following structure and function. The light guide board is provided on the front or back sides of a display screen. A sidelight is provided at an end of the light guide board

so as to irradiate the display screen via the light guide board. When the surrounding environment is bright, the sidelight is turned off, and ambient light incoming to the display screen is reflected by a reflection portion so that  
5 display is performed in a reflection mode. When the surrounding environment is dark, the sidelight is turned on and the display screen is irradiated by the sidelight so that display is performed in a transmission mode. In this case, the above-described problem occurs similarly.

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In the "display apparatus" disclosed in Japanese Laid-Open Publication No. 6-214508, the luminance and contrast of the display device are adjusted depending on the brightness of the surrounding environment. Therefore,  
15 images and videos are easily viewable on the entire display screen. However, characters displayed on the display screen are not always easily viewable.

In the case of this display apparatus in which  
20 luminance and contrast are adjusted over the display device, it is difficult to suppress color noise and/or a change in the apparent thickness of a character by the above-described display control method used in the "character display apparatus" disclosed in Japanese Laid-Open Publication

No. 2001-100725, in which a correction pattern is provided for each subpixel so as to display characters or graphics. Further, since a display device is controlled depending on the brightness of the surrounding environment, a sensor has  
5 to be provided around the display device.

#### DISCLOSURE OF THE INVENTION

According to an aspect of the present invention, a  
10 display apparatus is provided, which comprises: a display device including a display screen for displaying characters and/or graphics, in which each of the characters and/or graphics contains a basic portion and a neighboring portion arranged in the vicinity of the basic portion; and a control section for controlling the display device. The control section sets a luminance level of the basic portion and a  
15 luminance level of the neighboring portion in accordance with the intensity of light for irradiating the display screen. The control section controls the display device so that the  
20 character and/or graphics are displayed on the display screen using the set luminance level of the basic portion and the set luminance level of the neighboring portion.

In one embodiment of this invention, the control

section corrects at least one of the luminance level of the basic portion and the luminance level of the neighboring portion in accordance with the intensity of light for irradiating the display screen.

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In one embodiment of this invention, the control section sets the luminance level of the neighboring portion so that the luminance level of the neighboring portion is changed stepwise with an increase in a distance from the  
10 basic portion.

In one embodiment of this invention, the control section sets the luminance level of the basic portion and the luminance level of the neighboring portion based on  
15 luminance levels of a plurality of color elements.

In one embodiment of this invention, the display screen contains a plurality of pixels; each of the plurality of pixels contains a plurality of subpixels; and each of  
20 the plurality of subpixels is associated with one of a plurality of color elements.

In one embodiment of this invention, the basic portion and the neighboring portion are assigned the plurality of

subpixels.

In one embodiment of this invention, the display apparatus further comprises a light irradiation section for irradiating the display screen with light. The control section sets the luminance level of the basic portion and the luminance level of the neighboring portion in accordance with the intensity of light to be emitted from the light irradiation section to the display screen.

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In one embodiment of this invention, the control section sets the luminance level of the basic portion and the luminance level of the neighboring portion in accordance with the on or off state of the light irradiation section.

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In one embodiment of this invention, the control section sets the luminance level of the basic portion and the luminance level of the neighboring portion in accordance with an irradiation level indicating the intensity of light to be emitted from the light irradiation section to the display screen.

In one embodiment of this invention, the display apparatus further comprises a light irradiation section for

irradiating the display screen with light. The display device includes a display medium and a reflection section. The light irradiation section is disposed at a rear of the display medium. The control section switches between a 5 transmission mode in which light to be emitted from the light irradiation section is transmitted through the display medium when the light irradiation section is on, and a reflection mode in which light incident from a front of the display medium and transmitted through the display medium is reflected by the reflection section when the light irradiation section is off. The control section sets the 10 luminance level of the basic portion and the luminance level of the neighboring portion in accordance with the transmission mode or the reflection mode.

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In one embodiment of this invention, the display apparatus further comprises a memory section for storing a plurality of correction pattern tables indicating the luminance level of the basic portion and the luminance level 20 of the neighboring portion. The control section selects one of the plurality of correction pattern tables in accordance with the intensity of light for irradiating the display screen, and sets the luminance level of the basic portion and the luminance level of the neighboring portion in accordance

with the selected correction pattern table.

In one embodiment of this invention, the plurality of correction pattern tables are dependent on the intensity  
5 of light for irradiating the display screen.

In one embodiment of this invention, the display apparatus further comprises an input section for setting the intensity of light to be emitted from the light irradiation  
10 section.

In one embodiment of this invention, the display apparatus further comprises an input section for inputting information related to a viewer viewing the display device.  
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In one embodiment of this invention, the viewer-related information includes at least one of information related to the viewer's age, information related to the viewer's eye condition, and information related to  
20 the viewer's preference.

According to another aspect of the present invention, a display control method for displaying characters and/or graphics on a display screen is provided, in which each of

the characters and/or graphics contains a basic portion and a neighboring portion arranged in the vicinity of the basic portion. The method comprises the steps of: setting a luminance level of the basic portion and a luminance level of the neighboring portion in accordance with the intensity of light for irradiating the display screen; and displaying the character and/or graphics on the display screen using the set luminance level of the basic portion and the set luminance level of the neighboring portion.

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In one embodiment of this invention, the setting step includes correcting at least one of the luminance level of the basic portion and the luminance level of the neighboring portion in accordance with the intensity of light for irradiating the display screen.

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In one embodiment of this invention, the setting step includes setting the luminance level of the neighboring portion so that the luminance level of the neighboring portion is changed stepwise with an increase in a distance from the basic portion.

In one embodiment of this invention, the setting step includes setting the luminance level of the basic portion

and the luminance level of the neighboring portion based on luminance levels of a plurality of color elements.

In one embodiment of this invention, the display  
5 screen contains a plurality of pixels; each of the plurality of pixels contains a plurality of subpixels; and each of the plurality of subpixels is associated with one of a plurality of color elements.

10 In one embodiment of this invention, the display control method further comprises the step of setting the intensity of light to be emitted from a light irradiation section' to the display screen. The step of setting the luminance levels includes setting the luminance level of 15 the basic portion and the luminance level of the neighboring portion in accordance with the set intensity of light to be emitted from the light irradiation section to the display screen.

20 According to another aspect of the present invention, a program for displaying characters and/or graphics on a display screen is provided, in which each of the characters and/or graphics contains a basic portion and a neighboring portion arranged in the vicinity of the basic portion. The

program instructs a computer to execute the steps of: setting a luminance level of the basic portion and a luminance level of the neighboring portion in accordance with the intensity of light for irradiating the display screen; and displaying 5 the character and/or graphics on the display screen using the set luminance level of the basic portion and the set luminance level of the neighboring portion.

According to another aspect of the present invention, 10 a recording medium, storing a program for displaying characters and/or graphics on a display screen, is provided, in which each of the characters and/or graphics contains a basic portion and a neighboring portion arranged in the vicinity of the basic portion. The program instructs a 15 computer to execute the steps of: setting a luminance level of the basic portion and a luminance level of the neighboring portion in accordance with the intensity of light for irradiating the display screen; and displaying the character and/or graphics on the display screen using the set luminance 20 level of the basic portion and the set luminance level of the neighboring portion.

According to another aspect of the present invention, a display apparatus is provided, which comprises: a display

device including a display screen for displaying characters and/or graphics, in which each of the characters and/or graphics contains a basic portion and a neighboring portion arranged in the vicinity of the basic portion; and a control  
5 section for controlling the display device. The control section sets a luminance level of the basic portion and a luminance level of the neighboring portion in accordance with information related to a viewer of the display device. The control section controls the display device so that the  
10 character and/or graphics are displayed on the display screen using the set luminance level of the basic portion and the set luminance level of the neighboring portion.

In one embodiment of this invention, the control  
15 section corrects at least one of the luminance level of the basic portion and the luminance level of the neighboring portion in accordance with the viewer-related information.

In one embodiment of this invention, the  
20 viewer-related information includes at least one of information related to the viewer's age, information related to the viewer's eye condition, and information related to the viewer's preference.

In one embodiment of this invention, the control section sets the luminance level of the neighboring portion so that the luminance level of the neighboring portion is changed stepwise with an increase in a distance from the  
5 basic portion.

In one embodiment of this invention, the control section sets the luminance level of the basic portion and the luminance level of the neighboring portion based on  
10 luminance levels of a plurality of color elements.

In one embodiment of this invention, the display screen contains a plurality of pixels; each of the plurality of pixels contains a plurality of subpixels; and each of  
15 the plurality of subpixels is associated with one of a plurality of color elements.

In one embodiment of this invention, the basic portion and the neighboring portion are assigned the plurality of  
20 subpixels.

In one embodiment of this invention, the display apparatus further comprises a memory section for storing a plurality of correction pattern tables indicating the

luminance level of the basic portion and the luminance level of the neighboring portion. The control section selects one of the plurality of correction pattern tables in accordance with the viewer-related information, and sets the luminance  
5 level of the basic portion and the luminance level of the neighboring portion in accordance with the selected correction pattern table.

In one embodiment of this invention, the display  
10 apparatus further comprises an input section for inputting the viewer-related information.

According to another aspect of the present invention, a display control method for displaying characters and/or graphics on a display screen is provided, in which each of the characters and/or graphics contains a basic portion and a neighboring portion arranged in the vicinity of the basic portion. The method comprises the steps of: setting a luminance level of the basic portion and a luminance level  
15 of the neighboring portion in accordance with information related to a viewer of the display screen; and displaying the character and/or graphics on the display screen using the set luminance level of the basic portion and the set luminance level of the neighboring portion.  
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In one embodiment of this invention, the setting step includes correcting at least one of the luminance level of the basic portion and the luminance level of the neighboring portion in accordance with the viewer-related information.

In one embodiment of this invention, the viewer-related information includes at least one of information related to the viewer's age, information related to the viewer's eye condition, and information related to the viewer's preference.

In one embodiment of this invention, the setting step includes setting the luminance level of the neighboring portion so that the luminance level of the neighboring portion is changed stepwise with an increase in a distance from the basic portion.

In one embodiment of this invention, the setting step includes setting the luminance level of the basic portion and the luminance level of the neighboring portion based on luminance levels of a plurality of color elements.

In one embodiment of this invention, the display

screen contains a plurality of pixels; each of the plurality of pixels contains a plurality of subpixels; and each of the plurality of subpixels is associated with one of a plurality of color elements.

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In one embodiment of this invention, the display control method further comprises the step of inputting the viewer-related information.

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According to another aspect of the present invention, a program for displaying characters and/or graphics on a display screen is provided, in which each of the characters and/or graphics contains a basic portion and a neighboring portion arranged in the vicinity of the basic portion. The 15 program instructs a computer to execute the steps of: setting a luminance level of the basic portion and a luminance level of the neighboring portion in accordance with information related to a viewer of the display screen; and displaying the character and/or graphics on the display screen using 20 the set luminance level of the basic portion and the set luminance level of the neighboring portion.

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According to another aspect of the present invention, a recording medium, storing a program for displaying

characters and/or graphics on a display screen, is provided,  
in which each of the characters and/or graphics contains  
a basic portion and a neighboring portion arranged in the  
vicinity of the basic portion. The program instructs a  
5 computer to execute the steps of: setting a luminance level  
of the basic portion and a luminance level of the neighboring  
portion in accordance with information related to a viewer  
of the display screen; and displaying the character and/or  
graphics on the display screen using the set luminance level  
10 of the basic portion and the set luminance level of the  
neighboring portion.

Functions of the present invention will be described  
below.

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According to the present invention, the luminance  
levels of the basic portion and the neighboring portion of  
a character and/or graphics can be set in accordance with  
the intensity of light for irradiating the display screen.

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The intensity of light for irradiating the display  
screen varies depending on the on/off state of the light  
irradiation section. The intensity of light for irradiating  
the display screen also varies depending on the irradiation

level of the light irradiation section.

For example, by switching between a correction pattern suitable for the on state of the light irradiation section and a correction pattern suitable for the off state of the light irradiation section in accordance with a change in the characteristic of the display device caused by the switching of the on/off state of the light irradiation section (e.g., a backlight, a frontlight, or a sidelight), color noise can be suppressed and a change in the apparent thickness of a line of a character and/or graphics can be suppressed.

When the irradiation level of the light irradiation section (e.g., a backlight, a frontlight, or a sidelight) is changed in a stepwise manner, a correction pattern is changed in accordance with the irradiation level (brightness) of the light irradiation section. Thereby, color noise can be suppressed and a change in the apparent thickness of a line of a character and/or graphics can be suppressed.

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An input section for inputting a value of the intensity of light to be emitted by the light irradiation section, may be provided. The luminance levels of the basic portion and the neighboring portion of a character and/or

graphics can be set in accordance with the intensity input by a user or viewer through the input section.

This input includes, for example, switching of the  
5 on/off state of the light irradiation section and setting  
of the irradiation level of the light irradiation section.

The luminance level of the basic portion and the  
luminance level of the neighboring portion of characters  
10 and/or graphics may be set in accordance with information  
related to a viewer of a display device.

The luminance level may be set in accordance with  
a viewer's age or the state of viewer's eyes (e.g., cataracts),  
15 or viewer's preference (e.g., a viewer likes characters  
and/or graphics displayed with thick lines or dark colors  
for easy perception), or a combination thereof, input through  
the input section.

20 The memory section for storing correction patterns  
may be provided. A plurality of tables indicating correction  
patterns depending on the intensity of light for irradiating  
the display screen are previously stored in the memory section.  
The tables are selected in accordance with the intensity

of light for irradiating the display screen. By selecting the tables in this manner, it is possible to easily change the correction patterns.

5           A correction pattern is provided, which is used for the case where the intensity (brightness) of light of the light irradiation section (e.g., a backlight, a frontlight, or a sidelight) to the display screen is maximum. Another correction pattern is provided, which is used for the case  
10          where the light intensity is minimum. A correction pattern for a case where the light intensity is neither maximum nor minimum, can be calculated based on the above-described two correction patterns. In this case, the memory section stores  
15          only the correction patterns for the case where the light intensity (brightness) is maximum and the case where the light intensity is minimum.

Thus, correction patterns can be switched in accordance with the intensity of light for irradiating the  
20          display screen. Therefore, as is different from conventional technology, it is not necessary to provide a sensor for sensing ambient brightness.

The luminance levels of the basic portion and the

neighboring portion of a character and/or graphics are set in accordance with information related to a viewer of the display device.

5           The information related to a viewer of the display device includes, for example, a viewer's age or the state of viewer's eyes (e.g., cataracts), or viewer's preference (e.g., a viewer likes characters and/or graphics displayed with thick lines or dark colors for easy perception), or  
10          a combination thereof. Such information may be input through the input section. The luminance levels may be set in accordance with such information.

15          A plurality of tables indicating correction patterns depending on information related to a viewer of the display device may be previously provided in the memory section. By selecting and referencing the table in accordance with the information related to a viewer of the display device, correction patterns can be easily switched.

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          Thus, the invention described herein makes possible the advantage of providing a display apparatus and display control method, in which the occurrence of color noise and/or an apparent change in a line of a character and/or graphics,

caused by the intensity of light for irradiating a display screen, can be suppressed, and characters and/or graphics can be displayed at high definition; a program for executing the display control method on a computer; and a recording medium storing the program.

These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A is a block diagram showing a major part 15 of a configuration of a display apparatus according to an embodiment of the present invention.

Figure 1B is a block diagram showing a major part of a configuration of a display apparatus according to another embodiment of the present invention.

Figure 2 is a schematic diagram showing an exemplary display screen in a display device of Figure 1A formed of pixels.

Figure 3 is a diagram showing an exemplary correction pattern table stored in an auxiliary memory device of Figure 1A.

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Figure 4 is a diagram showing an exemplary correction pattern table stored in the auxiliary memory device of Figure 1A, which is used when a light irradiation section is turned on.

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Figure 5 is a diagram showing an exemplary correction pattern table stored in the auxiliary memory device of Figure 1A, which is used when the light irradiation section is turned off.

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Figure 6 is a diagram showing an exemplary correction pattern table stored in the auxiliary memory device of Figure 1A, which is used when the light irradiation section is at irradiation level 4.

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Figure 7 is a diagram showing an exemplary correction pattern table stored in the auxiliary memory device of Figure 1A, which is used when the light irradiation section is at irradiation level 3.

Figure 8 is a diagram showing an exemplary correction pattern table stored in the auxiliary memory device of Figure 1A, which is used when the light irradiation section 5 is at irradiation level 2.

Figure 9 is a diagram showing an exemplary correction pattern table stored in the auxiliary memory device of Figure 1A, which is used when the light irradiation section 10 is at irradiation level 1.

Figure 10 is a flowchart showing an exemplary procedure of a character/graphics display program of Figure 1A.

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Figure 11 is another flowchart showing another exemplary procedure of the character/graphics display program of Figure 1A.

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Figure 12 is a diagram showing a character "/" (slash) displayed by a conventional technique, where the character is represented by a basic portion thereof whose color element level is set to a predetermined luminance level.

Figure 13 is a diagram showing the character "/" (slash) displayed by another conventional technique, where the color element level of the basic portion is set to a predetermined luminance level (luminance level 0) and the color element level of the neighboring portion is set to a luminance level different from the luminance level ("0") of the basic portion.

BEST MODE FOR CARRYING OUT THE INVENTION

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Hereinafter, the present invention will be described by way of illustrative examples with reference to the accompanying drawings.

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Figure 1A is a block diagram showing a major part of a configuration of a display apparatus according to an embodiment of the present invention.

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Characters and/or graphics displayed by the display apparatus are made of a basic portion corresponding to the core of the character and/or graphics (central skeleton) and a neighboring portion provided in the vicinity of the basic portion.

In Figure 1A, a display apparatus 100 comprises a display device 10 capable of color display, an input device 20 through which display information is input to the display apparatus 100, an auxiliary memory device 30 which stores a control program and data, a control section 40 for controlling the display device 10, and a display device irradiation section 50 for irradiating a display screen of the display device 10 with light.

The display device 10 can display one or more characters and/or graphics.

The control section 40 controls the display device 10 so that various information input through the input device 20 is displayed in accordance with the control program and data stored in the auxiliary memory device 30.

Information representing characters (including symbols) and/or graphics or information relating to a viewer of the display device 10 may be input through the input device 20 to the display apparatus 100.

The display apparatus 100 may be used as a display apparatus for a personal computer or a word processor, for

example. The display apparatus **100** may be used as a desktop or laptop display apparatus or other various types of display apparatus.

5           The display apparatus **100** may be incorporated into any information apparatus, such as an electronic apparatus. For example, the display apparatus **100** may be used in mobile information instruments (e.g., personal digital assistants and the like), mobile telephones (e.g., PHS (personal  
10          handyphone system) and the like), and communication apparatuses (e.g., typical telephones, facsimile machines, and the like).

15          The display device **10** displays information, such as characters and graphics, which are input through the input device **20**.

20          The input device **20** is used to input information representing characters and graphics to be displayed on the display device **10**. This information representing characters and graphics contains, for example, identification codes for identifying the characters and graphics and sizes indicating the dimensions of characters or graphics. Therefore, any input device through which

identification codes and the sizes of characters or graphics can be input, can be used as the input device 20.

Preferable examples of the input device 20 include  
5 keyboards, mouses, pen-type input devices, and the like. When the display apparatus 100 is a display apparatus of a mobile telephone, number keys for specifying telephone numbers or a microphone for inputting voice may be used as the input device 20 to enter character codes and character  
10 sizes.

When characters or graphics displayed on the display device 10 all have a single fixed size, the input of the size may be omitted. Further, when the display apparatus 100 is used as a display section of an information apparatus provided with a communication line connecting section for connecting to a communication line, such as the Internet and the like, messages included in electronic mail received over the communication line may be displayed on the display device 10. In this case, the communication line connecting section may act as the input device 20.

The auxiliary memory device 30 stores: a character/graphics display program 31 as a control program,

in which a procedure for displaying characters and/or graphics on a display screen of the display device 10 is described; and data 32 required for executing the character/graphics display program 31. As the auxiliary memory device 30, any readable recording medium may be used to store the character/graphics display program 31 and the data 32, including, for example, hard disk, CD-ROM, MOD, MD, DVD, IC card, optical card, and the like.

10           The auxiliary memory device 30 functions as a memory section for storing a plurality of correction pattern tables indicating the luminance levels of a basic portion and a neighboring portion.

15           The character/graphics display program 31 carries out the steps of: setting a predetermined value to the color element level of a subpixel corresponding to the basic portion of a character or graphics in accordance with a change in characteristics of the display device 10 caused by a change 20 in irradiation conditions (e.g., the on/off state of the display device irradiation section 50 or a change in the irradiation level); setting a predetermined value to the respective color element levels of subpixels of the neighboring portion; and displaying the characters or

graphics on a display screen. The color element levels of subpixels in a neighboring portion may be set to values which are changed stepwise from the predetermined color element level of the subpixel of the basic portion, depending on  
5 the distance from the basic portion in a horizontal direction and/or a vertical direction.

The character/graphics display program 31 may comprise a step of setting the color element level of a basic portion and the color element levels of subpixels in the neighboring portion, based on viewer-related information input through the input device 20 by a user or viewer. Viewer-related information includes, for example, the viewer's age or the state of the viewer's eyes (e.g., cataract),  
10 or the viewer's preference (e.g., the viewer likes characters or graphics displayed with thick lines for easy perception).  
15

The data 32 contain character/graphics data 32a defining shapes of characters and/or graphics, and a correction pattern table 32b described below in detail  
20 (Figure 3).

The character/graphics data 32a include, for example, bitmap data (basic portion data) defining basic

portions of characters and/or graphics in subpixels.

Note that, in the above description, the character/graphics display program 31 and the data 32 are stored in the auxiliary memory device 30 (e.g., a recording medium). The present invention is not limited to this.

For example, the character/graphics display program 31 and the data 32 may be stored in a main memory 42 or a ROM (not shown). Examples of ROM include, for example, mask ROM, EPROM, EEPROM, flash ROM, and the like. When the character/graphics display program 31 and the data 32 are stored in a ROM, a wide variety of programs and data can be easily performed by changing ROMs. Such a ROM scheme can be preferably applied to, for example, the case where the display apparatus 100 is a display section of a mobile terminal or a mobile telephone.

The recording medium for storing the character/graphics display program 31 and the data 32 may be a storage medium which stores programs and data, such as a memory, a semiconductor memory, or the like, which have a disk or card shape.

The recording medium for storing the character/graphics display program 31 and the data 32 may be a communication medium which is used to transmit programs and data over a communication network, i.e., which transmits 5 programs and data.

When the display apparatus 100 is incorporated with an electronic information apparatus comprising a communication line connecting section for connecting to a 10 communication line, such as the Internet, at least a part of the character/graphics display program 31 and the data 32 can be downloaded via the communication line. In this case, a loader program required for download may be provided in an ROM (not shown). Alternatively, such a program may be 15 installed into the main memory 42 of the control section 40 from the auxiliary memory device 30.

The control section 40 comprises a CPU (central processing unit) 41 and a main memory 42. The control 20 section 40 determines the color element levels of subpixels contained in a display screen of the display device 10 and controls the display device 10 to display characters and/or graphics on the display screen, based on the character/graphics display program 31 and the data 32.

Specifically, the control section 40 separately controls a plurality of color element levels set to to a plurality of subpixels arranged on the display screen of the display device 10 to display information representing characters and/or graphics input through the input device 20 on the display device 10.

The CPU 41 controls and monitors the display apparatus 100 as well as executing various control programs, such as the character/graphics display program 31 stored in the auxiliary memory device 30, and the like. The CPU 41 determines the color element levels of the basic portion and the neighboring portion of a character or graphics in accordance with light irradiation intensity with respect to a display screen or viewer-related information based on the character/graphics display program 31 or the data 32 stored in the main memory 42 to generate the character or graphics patterns. The generated pattern is temporarily stored in the main memory 42, and thereafter, is output as display data to the display device 10. The timing of outputting the character or graphics patterns to the display device 10 is controlled by the CPU 41.

The main memory 42 is a working memory for temporarily

storing data input through the input device 20, data to be displayed on the display screen of the display device 10, and the character/graphics display program 31 and data required to execute the character/graphics display 5 program 31. The main memory 42 may be accessed by the CPU 41 at a high rate.

The display device irradiation section 50 irradiates the display screen of the display device 10 with 10 light. The display device irradiation section 50 may be, for example, a backlight, a frontlight, a sidelight, or the like. The light intensity (brightness) of the display device irradiation section 50 can be controlled in an on/off manner or in a stepwise or sequential manner in accordance with 15 an operating input through the input device 20. The display device irradiation section 50 may also be controlled so that the display device irradiation section 50 is automatically turned on when the display apparatus 100 is switched on or data is input to the input device 20, and after a predetermined 20 period of time, the display device irradiation section 50 is automatically turned off.

Figure 1B is a block diagram showing a major part of a configuration of a display apparatus according to another

embodiment of the present invention.

A display apparatus 200 shown in Figure 1B is substantially the same as the display apparatus 200 of Figure 1A, except that a liquid crystal display device 10a is used instead of the display device 10.

In the display apparatus 200, a display device irradiation section 50 is disposed behind the liquid crystal display device 10a.

The liquid crystal display device 10a comprises a transmissive substrate 11, a reflective substrate 12, a liquid crystal layer 13 interposed between the transmissive substrate 11 and the reflective substrate 12.

The reflective substrate 12 is provided with a reflection section 14 for reflecting light which has been transmitted through the transmissive substrate 11 and the liquid crystal layer 13.

Light emitted by the display device irradiation section 50 is also transmitted through a region of the reflective substrate 12 on which the reflection section 14

is not provided, and is further transmitted through the liquid crystal layer 13 and the transmissive substrate 11. The light is used for display of the liquid crystal display device 10a.

5

The CPU 41 of the control section 40 turns on the display device irradiation section 50 when the surrounding environment is dark, so that the display device irradiation section 50 irradiates the display screen with light and the liquid crystal display device 10a performs display in the transmission mode. When the surrounding environment is bright, the display device irradiation section 50 is turned off to reduce power consumption. In this case, ambient light incoming to the display screen 11 is reflected by the reflection section 14 so that the liquid crystal display device 10a performs display in the reflection mode. Thus, two display modes are switched.

Figure 2 is a schematic diagram showing an exemplary display screen in the display device 10 of Figure 1A.

The display device 10 is, for example, a color liquid crystal display device.

In Figure 2, a display screen 11 of the display device 10 has a plurality of pixels 12 in a matrix having an X direction and a Y direction. Each pixel 12 has a plurality of subpixels arranged in the X direction. Here, 5 each pixel has three subpixels corresponding to three primary colors (i.e., subpixel 14R, 14G, 14B).

The subpixel 14R is previously set to a color element R so as to exhibit a red color (R). The subpixel 14G 10 is previously set to a color element G so as to exhibit a green color (G). The subpixel 14B is previously set to a color element B so as to exhibit a blue color (B).

The color element levels (e.g., luminance levels) 15 of the subpixels 14R, 14G, and 14B are represented by a value of, for example, 0 to 255 (0x00 to 0xff where the notation "0x" represents the hexadecimal number system). If the subpixels 14R, 14G, and 14B separately take any luminance level of 0 to 255, about 16,700,000 (=256×256×256) colors 20 can be displayed.

Examples of the display device 10 include transmissive liquid crystal display devices predominantly used for personal computers and the like, as well as reflective

or rear-projection liquid crystal display devices. The display device 10 is not limited to color liquid crystal display devices. As the display device 10, any color display apparatus having a plurality of pixels arranged in the X and Y directions (e.g., XY matrix display apparatus) can be used.

The number of subpixels contained in a single pixel 12 is not limited to 3 (three primary colors). A single pixel 12 may contain a plurality of subpixels arranged in a predetermined direction. For example, when N color elements are used to represent colors, a single pixel 12 may contain N subpixels.

The arrangement sequence of the subpixels 14R, 14G, and 14B is not limited to that shown in Figure 2. For example, the sequence of B, G and R in that order in the X direction may be used instead of the sequence of R, G, and B in that order.

20

The direction of the arrangement of the subpixels 14R, 14G, and 14B is not limited to the direction shown in Figure 2 (the X direction). Alternatively, the subpixels 14R, 14G, and 14B may be arranged in the Y direction.

Color elements applicable to the present invention  
are not limited to red (R), green (G), and blue (B). For  
example, cyan (C), yellow (Y), and magenta (M) may be used  
5 as color elements.

Figure 3 is a diagram showing a correction pattern  
table 321b which is an example of the correction pattern  
table 32b stored in the auxiliary memory device 30 of  
10 Figure 1A.

In the following description, a process for  
displaying either a character or graphics on the display  
screen 11 of the display device 10 will be described.  
15

By storing the correction pattern table 321b of  
Figure 3 in the auxiliary memory device 30 (Figure 1A), the  
color element level (the luminance level of a color element)  
of a subpixel can be easily changed.

20 The control section 40 assigns "0" (black) to the  
color element level (luminance level) of subpixels  
corresponding to the basic portion of a character or graphics.  
Also, the control section 40 assigns "luminance level 73",

"luminance level 182", and "luminance level 219" to the color element levels of subpixels 1 to 3 neighboring a subpixel corresponding to the basic portion of a character or graphics, in order of distance from the basic portion, the nearest first, in accordance with the correction pattern table 32b. The control section 40 assigns "luminance level 255" to the color element level of subpixels corresponding to the background of the character or graphics.

Note that subpixel(s) of a neighboring portion refers to subpixel(s) which are located in the X direction or -X direction (horizontal direction) relative to a subpixel of the basic portion and within a distance equal to the length of the correction pattern where the distance is defined by the number of subpixels counted in the X or -X direction from the subpixel of the basic portion to the neighboring pixel. When subpixels are arranged in the Y direction within a pixel, subpixel(s) of a neighboring portion refer to subpixel(s) which are located in the Y direction or -Y direction (vertical direction) relative to a subpixel of the basic portion and within a distance equal to the length of the correction pattern where the distance is defined by the number of subpixels counted in the Y or -Y direction from the subpixel of the basic portion to the neighboring

pixel.

Thus, the correction pattern table **32b** is used to set the color element level (luminance level) of a subpixel in a neighboring portion arranged in the vicinity of a subpixel corresponding to the basic portion of a character or graphics. A neighboring portion contains at least one subpixel.

The color element level of a subpixel in a neighboring portion is defined in accordance with the distance from a subpixel corresponding to the basic portion of a character or graphics. For example, the color element level of subpixels of a neighboring portion of a character or graphics is designed to be monotonically increased as the distance from the basic portion of the character or graphics increases. In an exemplary increasing manner, the color element levels of neighboring subpixels 1 to 3 are set to "luminance level 73", "luminance level 182", and "luminance level 219" in the correction pattern table **321b** of Figure 3.

20

Here, the neighboring subpixel 1 is the nearest of the subpixels in a neighboring portion to a subpixel of the basic portion. The neighboring subpixel 2 is a subpixel that is the second nearest to the subpixel of the basic portion.

The neighboring subpixel 3 is a subpixel that is the third nearest to the subpixel of the basic portion.

In the correction pattern table **321b** of Figure 3,  
5 subpixels 1 to 3 in a neighboring portion have the same set  
of color element levels (luminance levels) irrespective of  
the color elements R, G, and B. However, a different set  
of luminance levels may be provided for each color element.  
10 For example, taking the characteristics of a display device  
for each of color elements R, G, and B into account, the  
luminance levels of color element levels may be appropriately  
set.

Further, in the correction pattern table **321b** of  
15 Figure 3, three neighboring subpixels (neighboring  
subpixels 1 to 3) are provided for a subpixel corresponding  
to the basic portion of a character or graphics. The present  
invention is not limited to this. For example, there may  
be four neighboring subpixels for a subpixel corresponding  
20 to a basic portion.

The correction pattern table **321b** of Figure 3 is used  
when a display attribute of a character or graphics is "normal  
display". As used herein, the term "normal display" refers

to display in which the background is displayed as being white and characters or graphics are displayed as being black. The present invention is not limited to this.

5           The display attribute of a character or graphics may be "reverse display". As used herein, the term "reverse display" refers to display in which the background is displayed as being black and the character or graphics is displayed as being white.

10           When the display attribute of a character or graphics is "reverse display", the permutation of the luminance levels corresponding to the color element level in the correction pattern table **321b** may be reversed for each color element  
15           R, G, and B.

20           Note that the display attribute of a character or graphics refers to a combination of the color of the background of the character or graphics and the color of the character or graphics. By providing an appropriate correction pattern table **32b**, it is possible to display characters or graphics with any display attribute.

Figure 4 is a diagram showing a correction pattern

table 322b which is another example of the correction pattern table 32b stored in the auxiliary memory device 30 of Figure 1A. The correction pattern table 322b is used when the display device irradiation section 50 (e.g., a backlight) 5 is on.

The CPU 41 of the control section 40 reads the correction pattern table 322b from the auxiliary memory device 30 to the main memory 42, when the display device 10 irradiation section 50 (e.g., a backlight) is turned on. The color element levels of subpixels corresponding to the basic portion of a character or graphics are set to "luminance level 0". The color element levels of neighboring subpixels 1 to 3 in the neighboring portion of the character 15 or graphics are set to values in accordance with the correction pattern table 322b as follows. For color element R and color element G, the subpixels of the neighboring portion are set to "luminance level 40", "luminance level 120", and "luminance level 200" in order of distance from the basic portion, the nearest first. For color element B, the subpixels of the neighboring portion are set to "luminance 20 level 30", "luminance level 110", and "luminance level 190" in order of distance from the basic portion, the nearest first. For color elements R, G and B, the color element

levels of subpixels in the background of the character or graphics are set to "luminance level 255".

Figure 5 is a diagram showing a correction pattern table 323b which is another example of the correction pattern table 32b stored in the auxiliary memory device 30 of Figure 1A.

The correction pattern table 323b is used when the display device irradiation section 50 (e.g., a backlight) is off.

When the display device irradiation section 50 (e.g., a backlight) is turned off, the CPU 41 of the control section 40 reads the correction pattern table 323b from the auxiliary memory device 30 to the main memory 42. The color element levels of subpixels corresponding to the basic portion of a character or graphics are set to "luminance level 0". The color element levels of neighboring subpixels 1 to 3 in the neighboring portion of the character or graphics are set to values in accordance with the correction pattern table 323b as follows. For color element R and color element G, the subpixels of the neighboring portion are set to "luminance level 100", "luminance level 160", and

"luminance level 220" in order of distance from the basic portion, the nearest first. For color element B, the subpixels of the neighboring portion are set to "luminance level 90", "luminance level 150", and "luminance level 210" 5 in order of distance from the basic portion, the nearest first. For color elements R, G and B, the color element levels of subpixels in the background of the character or graphics are set to "luminance level 255".

10 Comparing the correction pattern table **322b** of Figure 4 with the correction pattern table **323b** of Figure 5, the basic portion of a character or graphics and the background portion have the same luminance levels, and the neighboring subpixels 1 to 3 in the neighboring portion of a character 15 or graphics have different values. The luminance levels provided by the correction pattern table **322b** (Figure 4) are lower than the corresponding luminance levels provided by the correction pattern table **323b** (Figure 5). Therefore, by reducing the luminance levels (toward "0" (black)) when 20 the backlight is turned on, the display of the neighboring subpixels 1 to 3 are caused to be closer to black, so that a line of a character or graphics is perceived as being darker. As a result, a change in the apparent thickness of a line in a character or graphics can be prevented.

Note that in the correction pattern table 322b of Figure 4 and the correction pattern table of Figure 5, only the luminance levels of the neighboring subpixels 1 to 3  
5 are corrected. The present invention is not limited to this. In the present invention, at least one of the luminance level of the basic portion and the luminance level of the neighboring portion may be corrected.

10 Note that regarding the correction pattern table 322b (Figure 4) and the correction pattern table 323b (Figure 5), a backlight is switched on or off as an example. In the case where a frontlight or a sidelight is switched on/off, similar correction pattern tables can be provided.  
15

Figure 6 is a diagram showing a correction pattern table 324b which is another example of the correction pattern table 32b stored in the auxiliary memory device 30 of Figure 1A. The correction pattern table 324b is used when  
20 the intensity of light of the display device irradiation section 50 (e.g., a backlight) is the highest (hereinafter referred to as level 4).

When the intensity of light of the display device

irradiation section 50 (e.g., a backlight) is at level 4, the CPU 41 of the control section 40 reads the correction pattern table 324b from the auxiliary memory device 30 to the main memory 42. The color element levels of subpixels  
5 corresponding to the basic portion of a character or graphics are set to "luminance level 0". The color element levels of neighboring subpixels 1 to 3 in the neighboring portion of the character or graphics are set to values in accordance with the correction pattern table 324b as follows. The  
10 subpixels of the neighboring portion are set to "luminance level 40", "luminance level 120", and "luminance level 200" in order of distance from the basic portion, the nearest first. The color element levels of subpixels in the background of the character or graphics are set to "luminance  
15 level 255".

Figure 7 is a diagram showing a correction pattern table 325b which is another example of the correction pattern table 32b stored in the auxiliary memory device 30 of  
20 Figure 1A. The correction pattern table 325b is used when the intensity of light of the display device irradiation section 50 (e.g., a backlight) is the second highest (hereinafter referred to as level 3).

When the intensity of light of the display device irradiation section 50 (e.g., a backlight) is at level 3, the CPU 41 of the control section 40 reads the correction pattern table 325b from the auxiliary memory device 30 to the main memory 42. The color element levels of subpixels corresponding to the basic portion of a character or graphics are set to "luminance level 0". The color element levels of neighboring subpixels 1 to 3 in the neighboring portion of the character or graphics are set to values in accordance with the correction pattern table 325b as follows. For color element R and color element G, the subpixels of the neighboring portion are set to "luminance level 50", "luminance level 130", and "luminance level 205" in order of distance from the basic portion, the nearest first. For color element B, the subpixels of the neighboring portion are set to "luminance level 45", "luminance level 125", and "luminance level 205" in order of distance from the basic portion, the nearest first. For color elements R, G and B, the color element levels of subpixels in the background of the character or graphics are set to "luminance level 255".

Figure 8 is a diagram showing a correction pattern table 326b which is another example of the correction pattern table 32b stored in the auxiliary memory device 30 of

**Figure 1A.** The correction pattern table **326b** is used when the intensity of light of the display device irradiation section **50** (e.g., a backlight) is the second lowest (hereinafter referred to as level 2).

5

When the intensity of light of the display device irradiation section **50** (e.g., a backlight) is at level 2, the CPU **41** of the control section **40** reads the correction pattern table **326b** from the auxiliary memory device **30** to the main memory **42**. The color element levels of subpixels corresponding to the basic portion of a character or graphics are set to "luminance level 0". The color element levels of neighboring subpixels 1 to 3 in the neighboring portion of the character or graphics are set to values in accordance with the correction pattern table **326b** as follows. For color element R and color element G, the subpixels of the neighboring portion are set to "luminance level 60", "luminance level 140", and "luminance level 210" in order of distance from the basic portion, the nearest first. For color element B, the subpixels of the neighboring portion are set to "luminance level 50", "luminance level 130", and "luminance level 210" in order of distance from the basic portion, the nearest first. For color elements R, G and B, the color element levels of subpixels in the background of

the character or graphics are set to "luminance level 255".

Figure 9 is a diagram showing a correction pattern table 327b which is another example of the correction pattern table 32b stored in the auxiliary memory device 30 of Figure 1A. The correction pattern table 327b is used when the intensity of light of the display device irradiation section 50 (e.g., a backlight) is the lowest (hereinafter referred to as level 1).

10

When the intensity of light of display device irradiation section 50 (e.g., a backlight) is at level 1, the CPU 41 of the control section 40 reads the correction pattern table 327b from the auxiliary memory device 30 to the main memory 42. The color element levels of subpixels corresponding to the basic portion of a character or graphics are set to "luminance level 0". The color element levels of neighboring subpixels 1 to 3 in the neighboring portion of the character or graphics are set to values in accordance with the correction pattern table 327b as follows. For color element R and color element G, the subpixels of the neighboring portion are set to "luminance level 70", "luminance level 150", and "luminance level 215" in order of distance from the basic portion, the nearest first. For

color element B, the subpixels of the neighboring portion are set to "luminance level 55", "luminance level 135", and "luminance level 215" in order of distance from the basic portion, the nearest first. For color elements R, G and B,  
5 the color element levels of subpixels in the background of the character or graphics are set to "luminance level 255".

Comparing the correction pattern tables 324b to 327b of Figures 6 to 9, the basic portion of a character or graphics  
10 and the background portion have the same luminance levels, and the neighboring subpixels 1 to 3 in the neighboring portion of a character or graphics have different values. As the intensity of light from a backlight increases, i.e.,  
15 the backlight becomes brighter, the luminance level is reduced.

By reducing the luminance levels (toward "0" (black)) when the intensity of light from a backlight is large, the display of the neighboring subpixels 1 to 3 are caused to  
20 be closer to black, so that a line of a character or graphics is perceived as being darker, i.e., thicker. As a result, a change in the apparent thickness of a line in a character or graphics can be prevented.

Further, comparing the correction pattern tables **324b** to **327b** of Figures **6** to **9**, as the intensity of light from a backlight is decreased, i.e., the backlight becomes darker, blueness increases. Therefore, the 5 luminance level of color element B is set to be lower than the luminance level of color element R and color element G.

For the correction pattern tables **324b** to **327b** of Figures **6** to **9**, the intensity of light of a backlight is 10 set to have four levels (i.e., levels 1 to 4). The present invention is not limited to this. When the intensity of light of a backlight has N levels (N: natural number of 2 or more), N correction pattern tables corresponding to the respective levels need to be provided.

15

Color element levels (luminance levels) are set for the correction pattern tables **324b** to **327b** of Figures **6** to **9**, assuming that blueness increases with an increase in the 20 intensity of light of a backlight. The present invention is not limited to this. Redness or greenness may increase, depending on the characteristics of a display device. In this case, color element levels are set so that uniform colors can be displayed in accordance with the characteristics of a display device.

For the correction pattern tables **324b** to **327b** of Figures **6** to **9**, the intensity of light of a backlight is controlled as an example. The intensity of light of a frontlight or a sidelight may be controlled in accordance with similar correction pattern tables.

Note that in the correction pattern tables **324b** to **327b** of Figures **6** to **9**, only the luminance levels of the neighboring subpixels 1 to 3 are corrected. The present invention is not limited to this. In the present invention, at least one of the luminance level of the basic portion and the luminance level of the neighboring portion may be corrected.

15

In the thus-configured display apparatus **100** of an embodiment of the present invention, the CPU **41** of the control section **40** executes a predetermined character/graphics display program **31**. According to the character/graphics display program **31**, for example, no matter whether the display device irradiation section **50** is turned on or off, color noise can be reduced and a change in the apparent thickness of a line of a character and/or graphics can be suppressed. As a result, characters and/or graphics can be

displayed at high definition. A character/graphics display control method executed by the character/graphics display program 31 will be described below.

5           Figure 10 is a flowchart of the character/graphics display program 31, which is executed by the control section 40.

10          As shown in Figure 10, in step S101, information relating to a character or graphics to be displayed on the display screen of the display device 10 is input. In this case, for example, the identification code and size of the character or graphics are input through the input device 20.

15          Next, in step S102, the basic portion data of the character or graphics corresponding to the input identification code and size is obtained and stored temporarily in the main memory 42.

20          Data associated with a basic portion is herein referred to as basic portion data.

The basic portion data may be bitmap data which defines the basic portion of the character or graphics in

subpixels. Dots constituting the basic portion data correspond to respective subpixels.

5           The basic portion data is obtained by reading out  
the character/graphics data 32a from the auxiliary memory  
device 30, for example.

10         Alternatively, as disclosed in Japanese Laid-Open  
Publication No. 2002-49366, the basic portion data may be  
generated from bitmap data representing the shape of a  
character or graphics in pixels.

15         Alternatively, as disclosed in Japanese Laid-Open  
Publication No. 2001-100725, the basic portion data may be  
generated from character or graphics outline information  
indicating the outlines of characters or graphics or skeleton  
data indicating the skeleton shapes of characters or  
graphics.

20         In step S103, each dot constituting the basic portion  
data is associated with a subpixel in the display screen 11  
(Figure 2) of the display device 10. This association is  
executed by taking into account the position of a character  
displayed on the display screen 11 of the display device

10. For example, when a character is displayed at the upper left corner of the display screen 11, the dot at the upper left corner constituting the basic portion data is associated with a subpixel at the upper left corner of the display  
5 screen 11.

In step S104, it is determined whether the display device irradiation section 50 (e.g., a backlight) is on or off.

10

When the display device irradiation section 50 (e.g., a backlight) is on, i.e., the result of determination in step S104 is "Yes", the procedure goes to step S105. When the display device irradiation section 50 (e.g., a backlight)  
15 is off, i.e., the result of determination in step S104 is "No", the procedure goes to step S106.

In step S105 (the display device irradiation section 50 (e.g., a backlight) is on), the correction pattern table 322b (Figure 4) is selected from the data 32 stored in the auxiliary memory device 30. The luminance levels of subpixels corresponding to the basic portion of a character or graphics, the luminance level of subpixels in a neighboring portion arranged in the vicinity of the basic portion, and  
20

the luminance levels of subpixels corresponding to the background of the character or graphics, are set to values in accordance with the selected correction pattern table **322b**.

5

In step S106 (the display device irradiation section **50** (e.g., a backlight) is off), the correction pattern table **323b** (Figure 5) is selected from the data **32** stored in the auxiliary memory device **30**. The luminance levels of subpixels corresponding to the basic portion of a character or graphics, the luminance level of subpixels in a neighboring portion arranged in the vicinity of the basic portion, and the luminance levels of subpixels corresponding to the background of the character or graphics, are set to values in accordance with the selected correction pattern table **323b**.

After step S105 or step S106, luminance data indicating the luminance level of each of a plurality of subpixels is transferred to the display device **10** in step S107. The luminance levels of subpixels of the display screen **11** of the display device **10** are controlled in accordance with the luminance data, so that a character or graphics is displayed on the display screen **11**.

According to the above-described character/graphics display control method, the luminance levels are lower when a backlight is on than when the backlight is off, so that 5 displayed characters or graphics have darker lines. Therefore, the line width of displayed characters or graphics appears to be larger. Thus, it is possible to suppress a change in the apparent thickness of a line of a character or graphics between when a backlight is on and when the 10 backlight is off. In either case of the on or off state of the backlight, the luminance level of color element B is set to be lower than the luminance level of color element R and color element G in accordance with characteristics of a liquid crystal display device, thereby making it possible 15 to suppress color noise.

In the thus-configured display apparatus 100 of an embodiment of the present invention, the CPU 41 of the control section 40 executes the character/graphics display program 31 in another manner as follows. Even if the 20 intensity of light emitted by the display device irradiation section 50 onto the display screen 11 is changed, color noise can be reduced and a change in the apparent thickness of a line of a character and/or graphics can be suppressed.

As a result, characters and/or graphics can be displayed at high definition. A character/graphics display control method executed by the character/graphics display program 31 will be described below.

5

Figure 11 is another flowchart of the character/graphics display program 31 (Figure 1A), which is executed by the control section 40.

10

As shown in Figure 11, in step S201, information relating to a character or graphics to be displayed on the display screen 11 of the display device 10 is input. Step S201 is performed in a manner similar to that in step S101 of Figure 10.

15

Next, in step S202, the basic portion data of the character or graphics corresponding to the input identification code and size is obtained and stored temporarily in the main memory 42. Step S202 is performed  
20 in a manner similar to that in step S102 of Figure 10.

In step S203, each dot constituting the basic portion data is associated with a subpixel in the display screen 11 (Figure 2) of the display device 10. Step S203 is performed

in a manner similar to that in step S103 of Figure 10.

In step S204, the brightness (irradiation level) of the display device irradiation section 50 (e.g., a backlight)  
5 is determined.

In this embodiment, the display device irradiation section 50 has four levels of brightness (irradiation levels), i.e., level 1 (lowest) to level 4 (highest). The level currently selected can be detected based on a level selection signal indicating a level which has been selected. When the irradiation level of the backlight is level 4, the procedure goes to step S205. When the irradiation level of the backlight is level 3, the procedure goes to step S206. When 10 the irradiation level of the backlight is level 2, the procedure goes to step S207. When the irradiation level of the backlight is level 1, the procedure goes to step S208.  
15

In step S205 (the brightness (irradiation level) of the display device irradiation section 50 (e.g., a backlight) is level 4), the correction pattern table 324b (Figure 6) is selected from the data 32 stored in the auxiliary memory device 30. The luminance levels of subpixels corresponding to the basic portion of a character or graphics, the luminance  
20

level of subpixels in a neighboring portion arranged in the vicinity of the basic portion, and the luminance levels of subpixels corresponding to the background of the character or graphics, are set to values in accordance with the selected  
5 correction pattern table 324b.

In step S206 (the brightness (irradiation level) of the display device irradiation section 50 (e.g., a backlight) is level 3), the correction pattern table 325b (Figure 7)  
10 is selected from the data 32 stored in the auxiliary memory device 30. The luminance levels of subpixels corresponding to the basic portion of a character or graphics, the luminance level of subpixels in a neighboring portion arranged in the vicinity of the basic portion, and the luminance levels of subpixels corresponding to the background of the character or graphics, are set to values in accordance with the selected  
15 correction pattern table 325b.

In step S207 (the brightness (irradiation level) of the display device irradiation section 50 (e.g., a backlight) is level 2), the correction pattern table 326b (Figure 8)  
20 is selected from the data 32 stored in the auxiliary memory device 30. The luminance levels of subpixels corresponding to the basic portion of a character or graphics, the luminance

level of subpixels in a neighboring portion arranged in the vicinity of the basic portion, and the luminance levels of subpixels corresponding to the background of the character or graphics, are set to values in accordance with the selected  
5 correction pattern table 326b.

In step S208 (the brightness (irradiation level) of the display device irradiation section 50 (e.g., a backlight) is level 1), the correction pattern table 327b (Figure 9)  
10 is selected from the data 32 stored in the auxiliary memory device 30. The luminance levels of subpixels corresponding to the basic portion of a character or graphics, the luminance level of subpixels in a neighboring portion arranged in the vicinity of the basic portion, and the luminance levels of subpixels corresponding to the background of the character or graphics, are set to values in accordance with the selected  
15 correction pattern table 327b.

After step S205, S206, S207, or step S208, luminance data indicating the luminance level of each of a plurality of subpixels is transferred to the display device 10 in step S209. In accordance with the luminance data, the luminance levels of the display screen 11 of the display device 10 are controlled in subpixels, so that a character  
20

or graphics is displayed on the display screen 11.

According to this character/graphics display control method, the lower luminance levels are displayed  
5 when the irradiation level of a backlight is greater (brighter) than when the irradiation level of the backlight is smaller (darker). Therefore, displayed characters or graphics have darker lines. Therefore, the line width of a displayed character or graphics appears to be larger. Thus,  
10 it is possible to suppress a change in the apparent thickness of a line of a character or graphics, even when the irradiation level of a backlight is changed.

As the irradiation level of a backlight is decreased,  
15 i.e., the backlight becomes darker, blueness increases due to the characteristics of a liquid crystal display device. Therefore, the luminance level of color element B is set to be lower than the luminance level of color element R and color element G. Thus, it is possible to suppress color  
20 noise.

Next, a method for preparing correction patterns will be described when the display device irradiation section 50 has N irradiation levels (brightness levels), where N is

an integer of 3 or more. In the auxiliary memory device 30, a correction pattern table for the case when the irradiation level (brightness) of the display device irradiation section 50 is the height, and a correction pattern table for the case when the irradiation level (brightness) of the display device irradiation section 50 is the lowest, are previously provided. For other irradiation levels, correction patterns are calculated based on these two tables. Hereinafter, a calculation method will be described.

10

Now it is assumed as follows. The display device irradiation section 50 has N irradiation levels (brightness levels). When the irradiation level is 1 (lowest), the luminance levels of neighboring subpixels 1 corresponding to respective color elements R, G, and B are  $R_{min1}$ ,  $G_{min1}$ , and  $B_{min1}$ , respectively, and similarly, the luminance levels of neighboring subpixels 2 corresponding to respective color elements R, G, and B are  $R_{min2}$ ,  $G_{min2}$ , and  $B_{min2}$ , respectively. Similarly, the luminance levels of neighboring subpixels 3 corresponding to respective color elements R, G, and B are  $R_{min3}$ ,  $G_{min3}$ , and  $B_{min3}$ , respectively.

20  
Further, when the irradiation level is N (height), the luminance levels of neighboring subpixels 1

corresponding to respective color elements R, G, and B are Rmax1, Gmax1, and Bmax1, respectively. Similarly, the luminance levels of neighboring subpixels 2 corresponding to respective color elements R, G, and B are Rmax2, Gmax2, 5 and Bmax2, respectively. Similarly, the luminance levels of neighboring subpixels 3 corresponding to respective color elements R, G, and B are Rmax3, Gmax3, and Bmax3, respectively.

10           When the irradiation level (brightness) of the display device irradiation section 50 is M where M is an integer which is greater than or equal to 1 and smaller than or equal to N, the luminance level of color element R of the neighboring subpixel 1 is represented by Rm1, the 15 luminance level of color element G of the neighboring subpixel 1 is represented by Gm1, and the luminance level of color element B of the neighboring subpixel 1 is represented by Bm1. Each value is calculated as follows.

20            $Rm1 = ((Rmin1-Rmax1)/(N-1)) \times (M-1) + Rmin1$   
               $Gm1 = ((Gmin1-Gmax1)/(N-1)) \times (M-1) + Gmin1$   
               $Bm1 = ((Bmin1-Bmax1)/(N-1)) \times (M-1) + Bmin1$

Similarly, the luminance level of color element R

of the neighboring subpixel 2 is represented by Rm2, the luminance level of color element G of the neighboring subpixel 2 is represented by Gm2, and the luminance level of color element B of the neighboring subpixel 2 is  
5 represented by Bm2. Each value is calculated as follows.

$$Rm2 = ((Rmin2-Rmax2) / (N-1)) \times (M-1) + Rmin2$$

$$Gm2 = ((Gmin2-Gmax2) / (N-1)) \times (M-1) + Gmin2$$

$$Bm2 = ((Bmin2-Bmax2) / (N-1)) \times (M-1) + Bmin2$$

10

Similarly, the luminance level of color element R of the neighboring subpixel 3 is represented by Rm3, the luminance level of color element G of the neighboring subpixel 3 is represented by Gm3, and the luminance level  
15 of color element B of the neighboring subpixel 3 is represented by Bm3. Each value is calculated as follows.

$$Rm3 = ((Rmin3-Rmax3) / (N-1)) \times (M-1) + Rmin3$$

$$Gm3 = ((Gmin3-Gmax3) / (N-1)) \times (M-1) + Gmin3$$

20            $Bm3 = ((Bmin3-Bmax3) / (N-1)) \times (M-1) + Bmin3$

The luminance level of a subpixel corresponding to the basic portion of a character or graphics, and the luminance level of a subpixel corresponding to the background portion,

are constant irrespective of the irradiation level (brightness) of the display device irradiation section 50.

As described above, the correction pattern table for  
5 the case when the irradiation level (brightness) of the display device irradiation section 50 is the highest, and the correction pattern table for the case when the irradiation level (brightness) of the display device irradiation section 50 is the lowest, are stored in the auxiliary memory device 30. Correction patterns for irradiation levels between the highest irradiation level and the lowest irradiation level are obtained by calculation. Thus, it is possible to provide a correction pattern for any of the  
10 irradiation levels (brightness levels).  
15

In the above-described calculation, a correction pattern (e.g., luminance levels) corresponding to an irradiation level between the highest irradiation level and the lowest irradiation level, is obtained by linear interpolation. The present invention is not limited to this.  
20 Any function which is dependent on the characteristics of the display device 10 may be used.

The case where a backlight is used as the display

device irradiation section 50 is described above. The present invention is not limited to this. In the present invention, for example, a frontlight, a sidelight, or the like, may be provided as the display device irradiation 5 section 50.

In the above-described embodiments, the luminance levels of the basic portion and neighboring portion of characters and/or graphics are set in accordance with the 10 intensity of light for irradiating the display screen 11. The present invention is not limited to this.

In the present invention, the luminance levels of the basic portion and neighboring portion of characters 15 and/or graphics may be set in accordance with information related to a viewer of the display device 10.

Specifically, some user or viewer of the display device 10 may have difficulty in viewing the display of 20 characters and graphics, for example, due to the condition of the user's eyes (e.g., cataracts). In such a situation, a correction pattern table suitable for such a user may be provided and stored in the auxiliary memory device 30. This correction pattern table may be selected based on a user's

instruction input through the input device 20. The luminance levels (correction pattern) of subpixels corresponding to a basic portion and subpixels corresponding to a neighboring portion may be set in accordance with the 5 correction pattern table.

Further, the luminance levels of the basic portion and the neighboring portion of characters and/or graphics may be set based on both the intensity of light emitted onto 10 the display screen 11 and information related to a viewer of the display device 10.

According to the above-described embodiments, the color element levels (luminance levels) of subpixels 15 corresponding to the basic portion and the neighboring portion of a character and/or graphics are set in accordance with a correction pattern which is provided by considering the on/off state or irradiation levels of the display device irradiation section 50. For example, when the level of 20 irradiation of the display device 10 is great, the luminance levels of the subpixels in a neighboring portion are set to be low. In this case, a line of a character and/or graphics is perceived as being darker, i.e., the line appears to be thicker. As a result, a change in the apparent thickness

of a line in a character and/or graphics can be prevented. Therefore, by setting the luminance levels of subpixels in accordance with the irradiation intensity (on/off state or irradiation level) to the display screen 11, color noise  
5 can be suppressed and a change in the apparent thickness of a line of a character or graphics can be suppressed, resulting in high-definition display of the character and/or graphics. Thus, as is different from conventional technology, a sensor for detecting the intensity of light  
10 need not be provided around the display device 10.

In the above-described embodiments, the display device is capable of displaying colors. The present invention is not limited to this. The present invention can  
15 be applied to any display device capable of displaying gray levels. The display device may be capable of displaying only black and white.

In the above-described embodiments, the luminance  
20 level of a neighboring portion is corrected in accordance with the intensity of light for irradiating a display screen or information related to a viewer of a display device. The present invention is not limited to this. In the present invention, by correcting the luminance level of the basic

portion of a character or graphics, color noise can be suppressed and a change in the apparent thickness of a line of the character and/or graphics can be suppressed, resulting in the high-definition display of the character and/or  
5       graphics.

#### INDUSTRIAL APPLICABILITY

According to the present invention, the luminance  
10      levels of the basic portion and the neighboring portion of  
a character and/or graphics are set in accordance with the  
intensity of light for irradiating a display screen (e.g.,  
the on/off state of a light irradiation section or the  
15      irradiation level of the light irradiation section).  
Therefore, it is possible to provide a correction pattern  
suitable for a change in the characteristic of a display  
device caused by the on/off state of the light irradiation  
section or a change in the irradiation level. As a result,  
color noise can be suppressed and a change in the apparent  
20      thickness of a line of a character and/or graphics caused  
by ambient brightness can be suppressed.

Further, correction pattern tables are stored in a  
memory section. By selecting one of the correction pattern

tables in accordance with the intensity of light for irradiating a display screen, correction patterns can be easily switched. Thus, as is different from conventional technology, a sensor for sensing ambient brightness is not required.

Furthermore, characters and/or graphics can be displayed in a manner which is suitable for a viewer in accordance with information related to a viewer of a display device (e.g., the viewer's age, eye condition, or the like).

Furthermore, correction pattern tables are stored in a memory section. By selecting one of the correction pattern tables in accordance with viewer-related information, correction patterns can be easily switched.

Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.